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Department of Agriculture
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The United Kingdom Fishery for the Deep Water Shrimp *Pandalus borealis* in the North Sea

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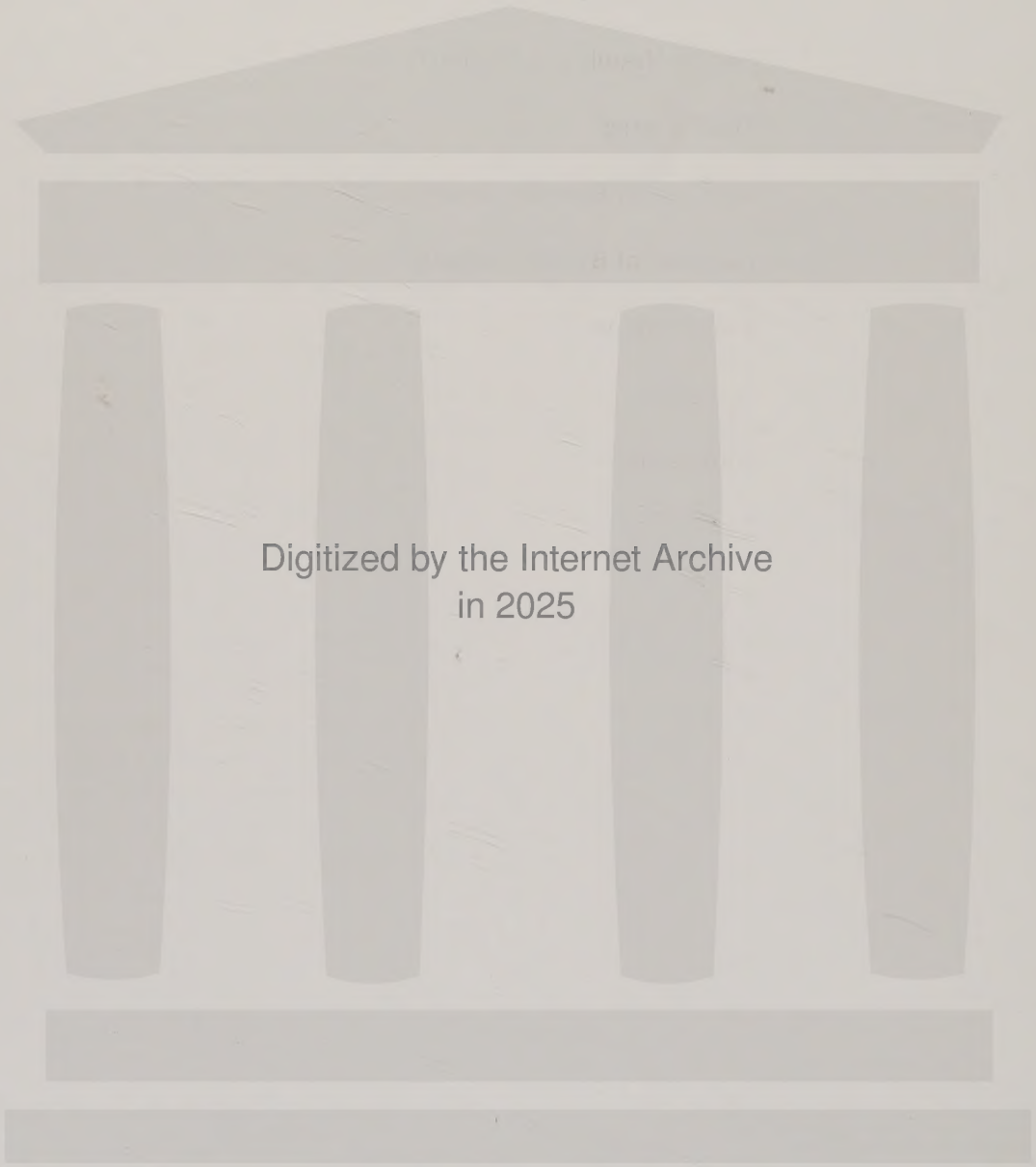

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The United Kingdom Fishery for the Deep Water Shrimp in the North Sea *Pandalus borealis*

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Introduction

The United Kingdom has for many years been a net importer of shrimps (Pandalidae and Crangonidae) and prawns (Palaemonidae and Penaeidae). A high level of consumer demand has ensured a steady rise in the amount imported from around 5,000 tonnes valued at £5.5 million in 1971 to around 11,300 tonnes valued at £26.7 million in 1981. Of these imports pandalid shrimps in 1981 accounted for around 4,700 tonnes valued at £9.5 million. In the North Sea, *Pandalus borealis* Krøyer is found in two areas relatively close to the British coasts, the Fladen ground (ICES Division IVa) and the Farn Deeps (ICES Division IVb). Until recently both of these areas, but particularly Fladen, were fished for shrimp by German and Scandinavian, but not by British vessels. In 1970 the rising demand for shrimp products combined with improved marketing facilities led to a small fleet of Scottish vessels starting to fish for *P. borealis* on the Fladen ground.

The principal aim of this report is to describe the catch and by-catch in the UK *Pandalus borealis* fisheries, but it is appropriate to describe briefly the distribution and biology of the species.

Distribution

Pandalus borealis occurs in both the Atlantic and the Pacific Oceans. It is referred to by Ekman (1953) as a circumboreal species having a discontinous Atlanto-Pacific distribution. It is common on both eastern and western seaboards of North America, with commercially exploited populations off Alaska and British Columbia on the west and in the Gulf of Maine and off Cape Cod on the east. In the North Atlantic populations are exploited on the east and west coasts of Greenland and around Iceland and the Faroes. In the north-east Atlantic exploited populations of *P. borealis* extend from Franz Josef Land in the north, through the Barents Sea, down the west coast of Norway to the Skagerrak, and the North Sea. The distribution of *P. borealis* is restricted to areas where the sea bed is composed of a fine soft mud, and to depths generally between 80 and 650 m (Allen, 1959).

Adult *P. borealis* are restricted to waters of fairly high salinity. Although larval stages have been found in salinities of 32‰, the adults have only once been recorded in salinities less than 34‰; all other records range from 34.1 to 35.7‰. Temperature is one of the most important limiting factors. Adult shrimp have been taken from water with temperature ranging from -1.68°C to 11.13°C. Prolonged exposure to temperatures of less than -1°C is deleterious to stocks and has caused mass mortalities (Horsted & Smidt, 1956). The upper limit was thought to be 8°C (Rasmussen, 1953) but later studies found *P. borealis* living and breeding in temperatures as high as 11.1°C (Allen, 1959). The temperature range in the Farn Deeps off Northumberland is from 6° to 11.1°C and it is probable that the population here is living at the extreme upper limit of its temperature range.

Biology

In the North Sea, spawning commences in early October and lasts until December, when most of the mature females are berried. The eggs are pale green in colour when laid, darkening to a pale violet just prior to hatching, which starts in late March. After hatching, six larval stages are passed through before metamorphosis into young shrimp about three months after hatching (Hjort & Ruud, 1938). Growth of the young shrimp is rapid, the size increasing from about 40 mm total length five months after hatching to about 80 mm total length after 14 months. At about this size (15 mm carapace length in females) and some 17 months after hatching, sexual maturity is attained. Primary females become berried for the first time. Female *P. borealis* are of two types. Primary females develop female characteristics at metamorphosis, and remain female for life. Secondary females develop after sex reversal from males. After mating the males develop female characteristics and enter the transitional phase before becoming secondary females. No growth occurs in berried females, and when the eggs hatch, some 24 months after the parental hatching, primary and secondary females are the same size. Growth now continues at a slow rate until the second egg laying in October, at an age of 30 months. The shrimp have now almost reached their maximum size. Soon after the second brood hatch, about 38 months after the parental hatch, mortalities occur. High mortalities also occur at the periods of egg laying, and few shrimps at Fladen or in the Farn Deeps survive longer than 38 months.

Fishing Grounds

The two principal areas in the North Sea fished for *Pandalus borealis* by British vessels are the Fladen ground (ICES Division IVa) and the Farn Deeps (ICES Division IVb) (Fig. 1).

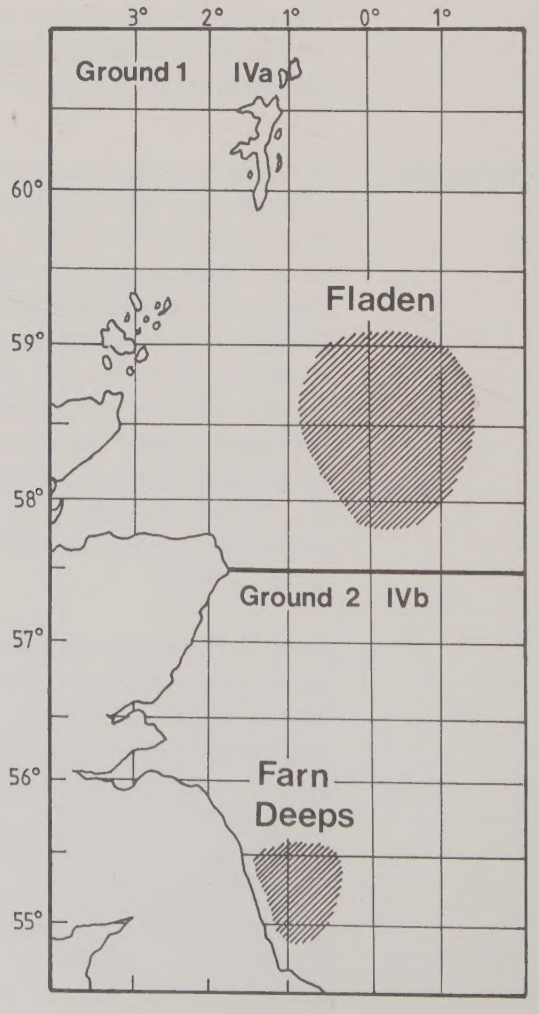

Figure 1. **Chart to show the Fladen and Farn Deep fishing grounds for *Pandalus borealis* in the North Sea. ICES sub-areas IVa and IVb.**

The area referred to as Fladen is situated some 90 miles NE of Peterhead and includes both the Fladen and Witch grounds. The area extends northwards for some 100 miles. The Farn Deeps lie some 15 miles off the coast of Northumberland, and the shrimp grounds extend southwards from the Farne Islands to the River Tees. Catches of *Pandalus sp.* have also been made in an area known as the Holes, some 60 miles east of Lerwick, and in the Moray Firth.

Fishing Ports

The British vessels which fish the Fladen grounds are all registered in Scottish ports, mainly Banff, Buckie, Fraserburgh and Peterhead. Landings of shrimp and associated by-catch are made at the ports of Buckie, Fraserburgh and Peterhead. The Farn Deeps are fished by both English- and Scottish-registered vessels. The English fleet consists principally of vessels registered at North and South Shields, Blyth and Berwick, although vessels registered at other ports also participate. Amongst the Scottish fleet, vessels registered at Leith predominate, but other ports of registry include Kirkcaldy, Buckie, Banff and Peterhead. Catches from this area are generally landed at North Shields, North Sunderland, Amble and Seahouses, but Scottish vessels make landings also at Eyemouth, Pittenweem and Leith.

Fishing Vessels and Fishing Gear

Vessels fishing the Fladen ground are generally in the size range 16-28 m with engines in the range 152-850 hp. Both wooden- and steel-hulled vessels are used. Vessels fishing the Farn Deeps tend to be smaller, with a size range of 14-17 m and with engines in the range 114-250 hp (Table I).

Table I. Overall Length and Engine HP of Scottish Vessels Employed in the North Sea Shrimp Fishery

	Overall length (M)	Engine size (HP)
Peterhead	18-26	200-660
Fraserburgh	19-28	152-850
Buckie	16-23	172-480
Eyemouth	15-17	114-250

The nets used at Fladen were initially Norwegian shrimp trawls with headline lengths of 51 and 55 m and with 1,200-1,400 meshes around the fishing circle. Subsequently Danish nets of a similar size were introduced and they are now widely used both there and in the Farn Deeps. At Fladen the larger vessels use Danish nets of 1,600 and 2,000 meshes.

Although the minimum mesh size, under the Fishing Nets (NE Atlantic) Order, 1977 was 16 mm until 1 April 1981, the stretched mesh size in the cod-end was usually 25-28 mm. On 1 April 1981 the minimum cod-end mesh size was increased in accordance with Council Regulation (EEC) No. 2527/80 to 30 mm stretched mesh.

The Fisheries

Fladen

The Scottish fishery at Fladen has been described by Howard (1978a). The fishery is seasonal, beginning about mid-March and extending until early autumn, although the peak has usually been passed by July. After a tentative start in 1970, the new fishery rapidly expanded after the installation in 1971 of peeling machinery in a processing plant near Inverness. The fishing fleet consisted of up to nine vessels, mainly from Peterhead and Fraserburgh. In 1974 vessels from the Buckie fleet joined the fishery and by 1976 up to 36 vessels were engaged in it including boats from Macduff (registered at Banff). Since 1976 the average number of vessels fishing per month has

remained fairly high at around 19 (Table II), although the length of the fishing season has been shortened.

Table II. The Average Number of UK Vessels Employed per Month in the North Sea Fishery for *Pandalus borealis*

		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Fladen (Area IVa)		3	5	4	4	5	8	14	20	34	15	13
Farn Deeps (Area IVb)	English registered								8	2	5	2
	Scottish registered								10	5	12	14

With the increase in size of the fleet came an increase in shore processing capacity. The increased facilities were expected to be used throughout the year to process *Pandalus* imported from countries outside the UK. However, the enlarged plant was greatly under-utilised and much has now been dismantled. The amount of plant now existing may be insufficient to process landings of shrimps at the 1978 level.

The Farn Deeps

A fishery started in the Farn Deeps as an extension of the Fladen fishery when weather conditions at the latter area were unsuitable for fishing, and was supplemented by vessels waiting in the early autumn for the start of the traditional Northumberland sprat fishery. Initially mainly Scottish vessels were involved, but English vessels started to participate and the fleet is now a mixed one and independent of the Fladen activity. Shrimps landed are generally sent north to the Scottish plants for processing.

Landings of *Pandalus borealis*

Weights and values of shrimp landings from Fladen are given in Tables III and IV and those from the Farn Deeps in Tables V-VIII. Mean annual landings by statistical rectangle of capture for the years 1974-1980 are shown in Figure 2.

At Fladen landings and catch per unit effort (cpue) rose steadily from 1970 to 1976. While landings continued to rise for a further two years, cpue started to decline (Fig. 3). After 1978 landings declined rapidly but cpue fell more slowly. The dramatic fall in landings is thought to have resulted primarily from a failure of recruitment, following fishery- induced depletion of the spawning stock. The possibility of such a failure was anticipated by ICES, which recommended an increase in the minimum mesh size to 35 mm (Anon., 1978).

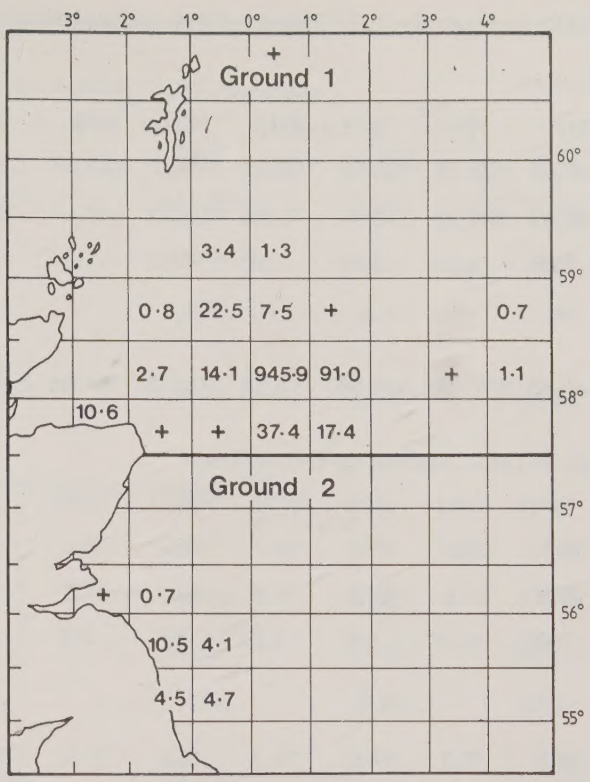

Figure 2. Mean annual landings (tonnes) of *Pandalus borealis* from the North Sea at Scottish ports by statistical rectangle of capture
Ground 1, for the years 1974-1980
Ground 2, for the years 1977-1980

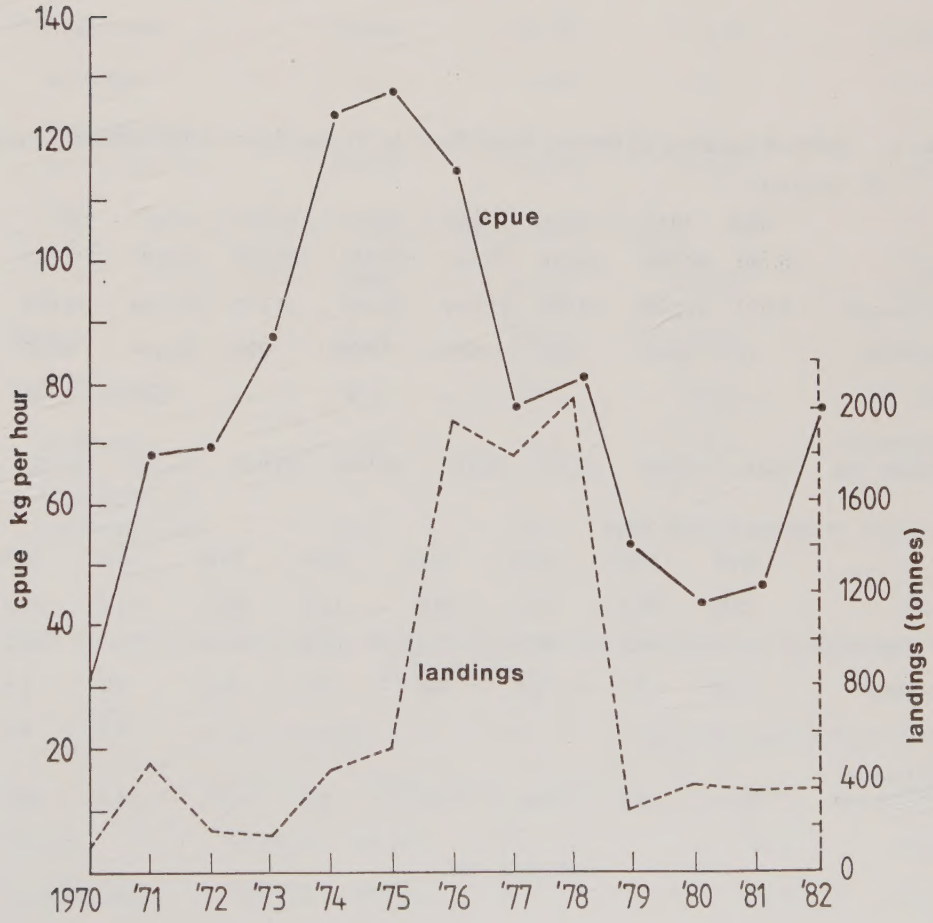

Figure 3. Landings and catch per unit effort of *Pandalus borealis* on the Fladen ground by Scottish vessels 1970-1982.

Table III. Landings of Shrimp and By-Catch Taken by Shrimp Trawl from the Fladen Ground by Scottish Vessels

(a) Weight (tonnes)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Shrimp	102.54	438.68	186.94	162.68	433.62	524.69	1,936.92	1,692.03	2,027.28	268.12	377.10	346.58
Total By-catch	149.53	286.35	110.94	75.98	103.80	146.12	525.49	791.07	627.01	137.78	254.49	171.65
Nephrops	0.05	15.86	3.56	1.40	13.62	1.14	51.48	8.42	7.49	4.39	5.09	11.75
Squids	–	–	–	–	–	–	4.82	3.30	3.10	–	–	–
Total Demersal and Pelagic Fish	149.48	270.49	107.38	74.58	90.18	144.98	469.19	779.35	616.42	133.39	249.40	159.90

(b) Percentage of Total Landings by Shrimp Trawl

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Shrimp	40.7	60.5	62.3	68.2	80.7	78.2	78.7	68.1	76.4	66.1	59.7	66.9
Total By-catch	59.3	39.5	37.2	31.8	19.3	21.9	21.3	31.9	23.6	33.9	40.3	33.1
Nephrops	0.02	0.02	1.2	0.05	2.5	0.2	2.1	0.3	0.3	1.1	0.8	2.3
Squids	–	–	–	–	–	–	0.2	0.1	0.1	–	–	–
Total Demersal and Pelagic Fish	59.3	37.3	36.0	31.2	16.8	21.6	19.1	31.4	23.2	32.9	39.5	30.9

Table IV. Value of Landings by Shrimp Trawl from the Fladen Grounds by Scottish Vessels

(a) Value (£)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Shrimp	20,186	82,190	32,588	43,131	150,561	180,469	768,937	924,992	1,435,768	249,398	361,144	291,146
Total By-catch	8,037	20,039	12,207	11,718	21,553	24,217	147,579	34,678	303,534	66,062	133,868	100,068
Nephrops	13	3,383	1,094	845	5,198	305	20,184	4,775	6,479	4,919	4,225	12,311
Squids	–	–	–	–	–	–	1,963	1,755	2,337	–	–	–
Total Demersal and Pelagic Fish	8,024	16,656	11,113	10,873	16,355	23,912	125,432	339,948	294,718	61,143	129,643	87,757

(b) Percentage of Total Value

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Shrimp	71.5	80.4	72.7	78.6	87.5	88.2	83.9	72.7	82.5	79.1	73.0	74.4
Total By-catch	28.5	19.6	27.3	21.4	12.5	11.8	16.1	27.3	17.5	20.9	27.0	25.6
Nephrops	0.05	3.3	2.4	1.5	3.0	0.1	2.2	0.4	0.4	1.5	0.8	3.1
Squids	–	–	–	–	–	–	0.2	0.1	0.1	–	–	–
Total Demersal and Pelagic Fish	28.4	16.3	24.8	19.8	9.5	11.7	13.7	26.7	16.9	19.4	26.4	22.4

Table V. Farn Deeps — Landings (tonnes) by Shrimp Trawl at English Ports

(a) By Scottish registered vessels

	1977	1978	1979	1980
Shrimp	145.33	57.57	157.16	170.24
Total By-catch	104.14	16.18	169.95	157.67
Nephrops	8.92	5.49	21.08	9.59
Total Demersal and Pelagic Fish	95.22	61.69	148.87	148.08

(b) By English registered vessels

	1977	1978	1979	1980
Shrimp	81.80	33.28	77.82	33.03
Total By-catch	38.35	43.70	101.87	89.99
Nephrops	4.26	0.75	10.03	2.57
Total Demersal and Pelagic Fish	34.09	42.95	91.84	87.42

(c) Total Landings by British Vessels

	1977	1978	1979	1980
Shrimp	227.13	90.85	234.98	203.27
Total By-catch	142.49	110.88	271.52	247.66
Nephrops	13.8	6.24	31.11	12.16
Total Demersal and Pelagic Fish	129.31	104.64	240.71	235.50

(d) Percentage of Total Landings by Shrimp Trawl

	1977	1978	1979	1980
Shrimp	61.4	45.0	46.4	45.1
Total By-catch	38.6	55.0	53.6	54.9
Nephrops	3.6	3.1	6.1	2.7
Total Demersal and Pelagic Fish	35.0	51.9	47.5	52.2

Table VI. Value of Landings by Shrimp Trawl from the Farn Deeps by British Vessels at English Ports

	(a) Value (£)				(b) Percentage of Total Value	
	1977	1978	1979	1980	1977	1978
Shrimp	129,624	54,141	Not available		67.5	57.5
Total By-catch	62,459	40,020			32.5	42.5
Nephrops	14,339	9,829			7.5	10.4
Total Demersal and Pelagic Fish	48,120	30,191			21.5	32.1

Table VII. Farn Deeps — Landings by Shrimp Trawl at Scottish Ports

	(a) Landings (tonnes)			(b) Percentage of total landings		
	1978	1979	1980	1978	1979	1980
Shrimp	2.30	34.30	17.34	76.7	74.3	75.1
Total By-catch	0.7	11.84	5.76	23.3	25.7	24.9
Nephrops	0.0	0.71	0.52	0.0	1.5	2.3
Total Demersal and Pelagic Fish	0.7	11.13	5.24	23.3	24.1	22.7

Table VIII. Value of Landings by Shrimp Trawl from the Farn Deeps at Scottish Ports

	(a) Value (£)			(b) Percentage of total value		
	1978	1979	1980	1978	1979	1980
Shrimp	1,289	23,404	13,204	80.1	77.7	79.6
Total By-catch	321	6,733	3,392	19.9	22.3	20.4
Nephrops	21	1,342	744	1.3	4.4	4.5
Total Demersal and Pelagic Fish	300	5,391	2,648	18.6	17.9	16.0

Landings of By-catch Species

In the UK fisheries by-catch of fish is landed principally for human consumption. A very small amount is occasionally landed for reduction to fish meal. Other by-catch species such as the Norway lobster, *Nephrops norvegicus* (L.) and the squid, *Loligo forbesi* (Steenstrup) are landed as and when they are captured, but their contribution to the total by-catch landing is, with minor exceptions, insignificant. The landings and values of all by-catch species by British vessels from the Fladen ground are given in Tables IX-XI, and those from the Farn Deeps in Tables XII-XIV. Earlier date on the Fladen by-catch by Scottish vessels have previously been presented by Howard (1976) and Howard & Mason (1972).

The total Scottish landings of demersal fish species from the Fladen area by all methods (Fig. 4) and by shrimp trawl (Fig. 5) are given by statistical rectangle of capture. The shrimp trawl landings constitute less than 1% of all Scottish demersal landings from the Fladen area. The landings of by-catch in the Danish fishery for *Pandalus* at Fladen have been described by Munch-Petersen (1981). In the Danish fishery landings of demersal fish constitute an insignificant part of the total Danish landings of demersal species.

Table IX. Landings (tonnes) of Shrimp and By-catch in the Scottish Shrimp Fishery at Fladen 1970-1981

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Shrimp	102.54	438.68	186.94	162.68	433.62	524.69	1,936.92	1,692.03	2,027.28	268.12	377.10	346.58
Total By-catch	149.53	286.35	110.94	75.98	103.80	146.12	525.49	791.07	627.01	137.78	260.38	171.65
Nephrops	0.05	15.86	3.56	1.40	13.62	1.14	51.48	8.42	7.49	4.39	5.09	11.75
Squids	-	-	-	-	-	-	4.82	3.30	3.10	-	-	-
Cod	50.84	87.62	67.69	42.61	57.74	69.77	207.13	298.98	277.88	40.62	90.17	57.39
Haddock	41.81	35.10	14.12	3.47	2.95	5.52	15.12	150.06	49.92	11.42	19.74	15.32
Whiting	6.06	11.96	7.33	1.09	1.92	4.15	15.86	19.09	30.22	36.43	46.20	7.85
Saithe	0.72	1.48	3.70	1.02	4.43	8.84	19.59	61.16	29.36	2.45	6.21	1.90
Hake	0.17	0.37	0.08	0.06	0.04	0.05	0.96	0.33	0.37	0.13	1.14	0.47
Lythe	-	-	-	-	-	0.01	-	0.10	0.12	-	-	0.28
Ling	1.70	3.63	1.95	4.51	1.16	4.58	12.27	25.83	27.08	5.65	13.59	12.25
Catfish	1.31	2.23	1.67	1.61	2.56	2.10	3.74	8.06	8.95	1.69	3.65	2.87
Monk	5.17	9.94	4.28	4.88	13.30	27.22	101.68	160.70	120.87	26.57	51.03	50.88
Plaice	0.13	0.18	0.25	0.10	0.03	-	0.15	1.42	0.68	0.70	0.45	0.18
Lemon sole	0.23	0.14	0.16	0.20	0.02	-	0.41	1.10	1.81	1.00	2.87	0.85
Witch	2.00	2.08	1.67	1.80	0.82	0.94	2.61	5.52	12.19	3.31	3.98	4.88
Dab	-	-	-	0.12	0.03	0.11	0.20	0.72	1.08	0.33	0.16	1.77
Halibut	0.65	0.95	0.42	0.05	0.13	0.18	0.51	0.83	0.86	0.20	0.42	0.30
Megrim	0.20	0.14	0.23	-	0.15	0.37	0.59	0.59	1.50	0.08	0.36	0.21
Turbot	0.02	0.16	0.06	0.03	0.10	0.03	0.04	0.13	0.73	0.11	0.22	0.11
Skate	0.44	1.00	0.43	0.51	0.29	0.87	1.06	1.87	2.86	0.46	1.18	0.53
Dogfish	0.64	9.37	2.85	3.59	4.51	14.27	20.78	40.13	38.64	2.28	6.75	1.88
Herring	-	0.12	0.36	-	-	-	-	-	-	-	-	-
Mackerel	-	-	-	-	-	0.04	-	0.77	0.27	-	-	-
Norway pout	37.39	103.00	-	8.92	-	5.93	66.44	-	-	-	-	-
Unspecified	-	1.02	0.13	-	-	-	0.05*	0.05†	-	-	0.01*	0.02#
Roes	-	-	-	0.01	-	-	-	-	0.03	0.01	0.64	0.01
Total Demersal and Pelagic Fish	149.48	270.49	107.38	74.58	90.18	144.98	469.19	779.35	616.42	133.39	249.90	159.90

*Brill †D.sole & Brill #-D.sole

Table X. Monthly Landings (tonnes) by Scottish Vessels of Shrimp and By-catch from Fladen (Means for the Years 1970-1975)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Shrimp	0.08	-	5.34	51.39	83.36	59.79	58.40	30.61	13.52	4.66	0.46	0.60
Total By-catch	0.01	-	1.40	19.04	21.74	29.46	34.00	20.07	10.71	8.01	0.69	0.31
Nephrops	0.01	-	-	1.97	0.21	0.15	1.68	0.45	0.85	0.46	0.11	0.02
Squids	-	-	-	-	-	-	-	-	-	-	-	-
Cod	-	-	0.47	9.34	10.58	12.44	12.75	9.11	5.66	2.51	0.17	0.05
Haddock	-	-	0.04	2.07	2.71	3.59	3.31	2.43	0.73	1.55	0.13	0.09
Whiting	-	-	0.09	0.81	0.50	0.81	0.59	0.63	0.86	0.99	0.21	0.07
Saithe	-	-	0.08	0.85	0.28	0.68	0.66	0.29	0.43	0.10	0.01	+
Hake	-	-	+	0.02	0.03	0.04	0.04	0.01	+	0.01	-	-
Lythe	-	-	-	-	-	-	-	-	-	+	-	-
Ling	-	-	0.02	0.34	0.78	0.63	0.39	0.43	0.30	0.04	-	-
Catfish	-	-	-	0.22	0.33	0.50	0.45	0.30	0.10	0.02	-	-
Monk	-	-	0.10	2.48	2.48	2.71	1.74	0.90	0.33	0.05	-	-
Plaice	-	-	-	0.01	0.03	0.01	0.02	0.03	-	+	0.01	+
Lemon sole	-	-	-	-	0.02	0.01	0.01	0.07	0.01	+	-	-
Witch	-	-	+	0.11	0.30	0.51	0.24	0.20	0.02	0.02	+	-
Dab	-	-	-	0.01	0.01	+	-	0.02	-	-	-	-
Halibut	-	-	+	0.07	0.07	0.08	0.07	0.05	0.03	0.03	-	-
Megrim	-	-	-	0.05	0.04	0.03	0.02	0.02	-	+	0.01	-
Turbot	-	-	-	0.01	0.02	0.02	0.01	0.01	+	-	-	+
Skate	-	-	+	0.12	0.12	0.08	0.12	0.13	0.02	0.01	-	+
Dogfish	-	-	+	0.56	2.70	0.69	0.38	0.90	0.28	0.44	0.01	0.08
Herring	-	-	-	-	-	-	-	0.02	0.01	0.02	0.03	-
Mackerel	-	-	-	-	-	-	-	0.01	-	-	-	-
Norway pout	-	-	0.60	-	0.53	6.48	11.37	4.06	1.08	1.74	-	-
Unspecified	-	-	-	-	-	-	0.17	-	-	0.02	-	-
Roes	-	-	-	-	-	+	-	-	-	-	-	-
Total Demersal and Pelagic Fish	-	-	1.40	17.07	21.53	29.31	32.32	19.62	9.86	7.55	0.58	0.29

Table XI. Monthly Landings (tonnes) of Shrimp and By-catch at Scottish Ports from the Fladen ground (Means for the Years 1976-1981)

	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.
Shrimp	0.07	96.88	270.98	201.19	343.10	154.58	32.10	8.00	0.92	0.18
Total By-catch	1.43	28.67	97.53	117.95	89.53	70.19	11.70	2.26	-	0.04
Nephrops	-	1.28	1.54	6.34	1.83	3.60	0.02	0.17	-	-
Squids	-	-	-	1.07	0.80	-	-	-	-	-
Cod	0.13	10.38	41.73	44.54	37.01	22.44	5.14	0.83	-	+
Haddock	0.08	2.22	5.80	10.83	10.80	11.25	2.00	0.23	-	-
Whiting	1.15	7.79	11.41	1.55	1.19	1.80	0.56	0.47	-	0.03
Saithe	0.01	0.71	6.38	6.32	3.40	3.66	2.02	0.14	-	-
Hake	-	0.06	0.18	0.31	0.08	0.04	0.01	-	-	-
Lythe	-	+	0.01	0.05	+	0.01	0.01	-	-	-
Ling	-	1.59	5.00	4.33	3.32	1.40	0.35	0.17	-	-
Catfish	0.01	0.15	0.76	1.39	1.50	0.90	0.13	0.01	-	-
Monk	0.05	3.53	21.97	28.35	21.83	9.05	0.83	0.17	-	-
Plaice	-	+	0.12	0.25	0.20	0.05	0.02	+	-	-
Lemon sole	-	0.02	0.14	0.26	0.41	0.41	0.09	0.02	-	+
Witch	+	0.27	1.17	1.62	1.79	0.70	0.06	0.03	-	-
Dab	-	0.01	0.08	0.31	0.34	0.04	0.02	+	-	-
Halibut	-	+	0.14	0.18	0.11	0.07	+	0.01	-	-
Megrim	-	0.04	0.16	0.12	0.18	0.20	+	-	-	-
Turbot	-	0.01	0.13	0.09	0.03	0.08	+	+	-	+
Brill	-	+	-	-	+	-	-	-	-	-
Dover sole	-	-	-	0.01	+	-	-	-	-	-
Skate	-	0.14	0.40	0.23	0.32	0.10	0.06	+	-	-
Dogfish	-	0.07	0.42	9.81	3.77	3.91	0.34	-	-	+
Herring	-	-	-	-	-	-	-	-	-	-
Mackerel	-	-	-	0.08	-	0.05	0.05	-	-	-
Norway pout	-	-	-	-	0.61	10.47	-	-	-	-
Roes	-	+	+	-	-	-	-	-	-	-
Total Demersal and Pelagic Fish	1.43	27.39	96.00	110.54	86.90	66.59	11.68	2.09	-	0.04

Table XII. Landings (tonnes) of Shrimp and By-catch from the Farn Deeps at English Ports, 1977-1980

Landings	By English Registered Vessels				By Scottish Registered Vessels				Total			
	1977	1978	1979	1980	1977	1978	1979	1980	1977	1978	1979	1980
Shrimp	81.80	33.28	77.82	33.03	145.33	57.57	157.16	170.24	227.13	90.85	234.98	203.27
Total By-catch	38.35	43.70	101.87	89.99	104.14	67.18	169.95	157.67	142.49	110.88	271.52	247.66
Nephrops	4.26	0.75	10.03	2.57	8.92	5.49	21.08	9.59	13.18	6.24	31.11	12.16
Cod	20.09	30.53	36.93	14.10	39.58	29.13	67.56	64.75	59.67	59.66	104.49	78.85
Haddock	1.65	0.35	5.83	33.47	19.15	4.32	11.13	33.12	20.80	4.67	16.96	66.59
Whiting	3.21	7.03	28.18	26.51	16.90	17.63	44.25	26.74	20.11	24.66	72.43	53.25
Saithe	-	-	-	-	-	-	-	-	-	-	-	-
Hake	-	-	-	-	-	-	-	-	-	-	-	-
Lythe	-	-	-	-	-	-	-	-	-	-	-	-
Ling	-	-	-	-	-	-	-	0.05	-	-	-	0.05
Catfish	-	-	-	-	-	-	-	-	-	-	-	-
Monk	0.07	0.32	0.17	0.03	0.49	0.32	1.27	0.26	0.56	0.64	1.44	0.29
Gurnard	-	-	-	-	0.39	-	-	-	0.39	-	-	-
Plaice	0.25	2.02	1.51	1.44	3.24	3.02	3.29	2.74	3.49	5.04	4.80	4.18
Lemon sole	1.24	1.03	4.53	1.12	4.76	3.45	8.06	4.40	6.00	4.48	12.59	5.52
Witch	0.11	-	0.16	-	0.85	0.52	0.47	0.15	0.96	0.52	0.63	0.15
Dab	-	0.05	0.25	0.20	0.05	-	0.31	-	0.05	0.05	0.56	0.20
Halibut	-	-	0.01	0.01	-	0.02	-	-	-	0.02	0.01	0.01
Megrim	-	-	-	-	-	-	-	-	-	-	-	-
Turbot	-	0.02	-	0.01	-	0.04	0.02	-	-	0.06	0.02	0.01
Skate	-	0.20	0.29	0.05	0.35	0.04	0.05	0.04	0.35	0.24	0.34	0.09
Dogfish	3.61	0.08	6.07	4.12	5.45	0.55	2.81	2.23	9.06	0.63	8.88	6.35
Herring	0.09	-	2.65	0.36	0.19	0.05	1.48	0.72	0.28	0.05	4.13	1.08
Mackerel	0.62	-	0.14	-	0.34	-	-	0.15	0.96	-	0.14	0.15
Sprat	-	-	-	-	-	-	-	0.05	-	-	-	0.05
Unspecified	3.11	1.32	4.81	6.12	4.52	2.55	8.78	12.57	7.63	3.87	13.59	18.69
Roes	-	-	-	-	-	-	0.01	-	-	-	0.01	-
Bib	-	-	-	-	-	0.05	-	-	-	0.05	-	-
Total Demersal and Pelagic Fish	34.09	42.95	91.84	87.42	95.22	61.69	148.87	148.08	129.31	104.64	240.71	235.50

Table XIII. Monthly Landings (tonnes) by British Vessels of Shrimp and By-catch from the Farn Deeps at English ports (Means for the Years 1977-1980)

	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.
Shrimp	0.41	15.49	32.16	86.24	16.72	16.10	18.01	3.93
Total By-catch	0.46	20.14	39.62	63.29	11.97	17.70	37.36	2.67
Nephrops	0.20	0.94	3.01	1.66	1.68	0.99	6.71	0.50
Cod	0.14	11.48	19.96	31.51	5.47	2.64	3.98	0.50
Haddock	0.01	0.80	4.74	12.24	0.74	3.90	4.80	0.04
Whiting	0.03	3.89	4.70	6.04	1.31	6.23	18.74	1.40
Hake	-	-	-	-	-	-	-	-
Saithe	-	-	-	-	-	-	-	-
Lythe	-	-	-	-	-	-	-	-
Ling	-	-	0.01	-	-	-	-	-
Bib	-	-	0.01	-	-	-	-	-
Catfish	-	-	-	-	-	-	-	-
Monk		0.20	0.15	0.23	0.08	0.05	0.02	0.02
Gurnard	-	-	0.01	-	0.09	-	-	-
Plaice	0.03	0.97	1.59	1.18	0.13	0.10	0.37	0.02
Lemon sole	0.01	1.07	1.75	2.57	0.61	0.46	0.66	0.08
Witch	0.01	0.11	0.09	0.18	0.07	0.06	0.04	-
Dab	-	0.01	0.18	0.03	-	-	-	-
Halibut	-	+	+	-	-	-	-	-
Megrim	-	-	-	-	-	-	-	-
Turbot	-	+	+	0.01	-	+	-	-
Skate	-	0.07	0.35	0.54	0.05	0.01	-	-
Dogfish	-	-	0.09	2.79	0.88	2.00	0.23	+
Herring	-	-	0.08	0.28	0.03	0.26	0.42	0.01
Mackerel	-	0.01	-	-	0.09	0.18	0.18	-
Sprat	-	-	-	-	-	-	0.01	-
Unspecified	0.03	0.66	3.19	4.05	0.76	0.82	0.78	0.15
Roes	-	+	-	-	-	-	-	-
Total Demersal and Pelagic Fish	0.26	19.20	36.61	61.63	10.29	16.71	30.66	2.17

Table XIV. Landings (tonnes) of Shrimp and By-catch at Scottish Ports from the UK fishery in the Farn Deeps

	1978	1979	1980
Shrimp	2.30	34.30	17.34
Total By-catch	0.72	11.86	5.76
Nephrops	0.01	0.73	0.52
Cod	0.50	7.19	3.36
Haddock	-	1.44	0.36
Whiting	0.01	1.14	0.29
Saithe	-	0.02	-
Hake	-	-	-
Lythe	-	-	-
Ling	-	-	0.01
Catfish	-	0.01	0.01
Monk	0.01	0.19	0.02
Plaice	0.10	0.22	0.19
Lemon sole	0.10	0.74	0.38
Witch	-	0.05	0.03
Dab	-	-	-
Halibut	-	-	0.01
Megrim	-	-	-
Turbot	-	0.02	0.01
Skate	-	-	-
Dogfish	-	0.11	-
Herring	-	-	-
Mackerel	-	-	-
Sprat	-	-	-
Unspecified	-	-	-
Roes	-	-	-
Total Demersal and Pelagic Fish	0.72	11.13	5.24

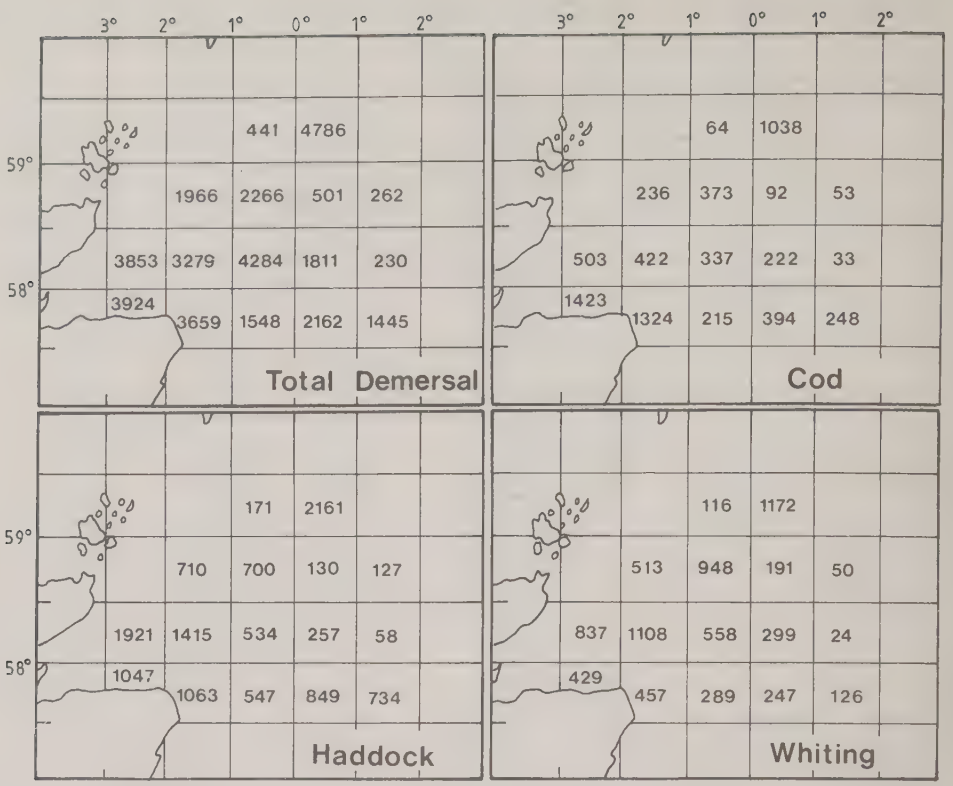

Figure 4. Annual landings (tonnes) of all demersal fish species from the Fladen area by statistical area of capture meaned for the years 1974-1980

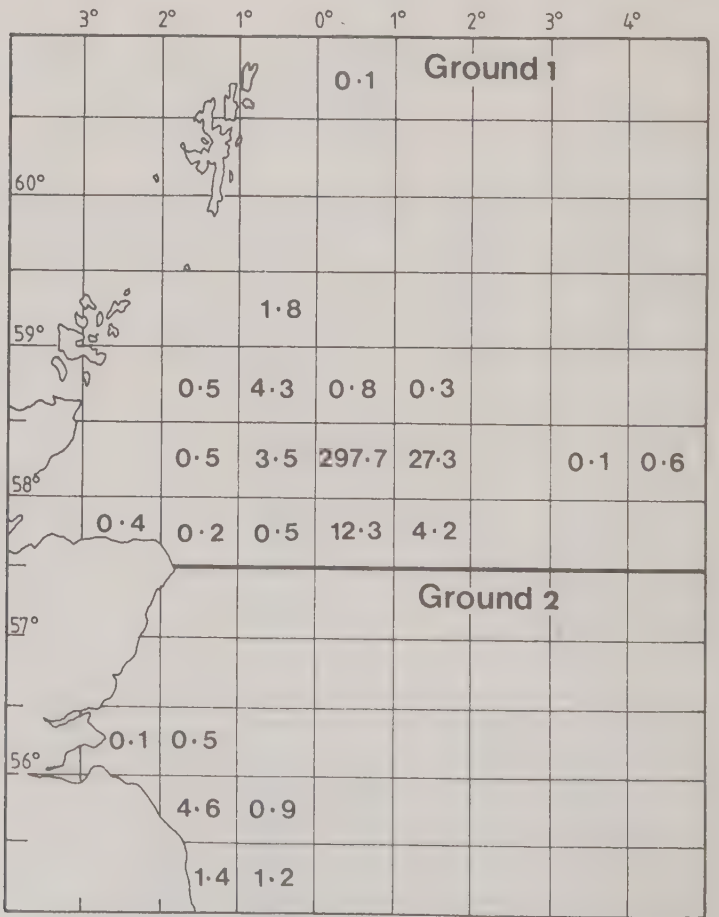

Figure 5. Mean annual landings (tonnes) of demersal fish species from the Fladen and Farn Deep areas taken by shrimp trawl by statistical area of capture
Ground 1, for the years 1974-1980
Ground 2, for the years 1977-1980

In the United Kingdom *Pandalus* fisheries, the principal fish species landed from both the Fladen and the Farn Deeps is cod. Cod, haddock and whiting constitute about 60% by weight of total fish landings from Fladen and about 82% of those from the Farn Deeps. At Fladen the total fish by-catch landings constitute about 30% by weight and about 21% by value of total Scottish deep water shrimp fishery landings. In the first year of the fishery, 1970, they were higher (59%) and in only two years did they fall below 20%. In the Farn Deeps, *Nephrops* accounts for about 3.8% of total United Kingdom by-catch landings, and total fish landings are generally higher in proportion to total landings than at Fladen, accounting for about 46% by weight and about 38% by value (Tables XV-XVII).

Table XV. Farn Deeps — Total landings by Shrimp Trawl by British Vessels

	Total (tonnes)				Percentage			
	1977	1978	1979	1980	1977	1978	1979	1980
Shrimp	227.13	93.15	269.28	220.61	61.4	45.5	48.7	46.5
Total By-catch	142.49	111.58	283.36	253.42	38.6	54.5	51.3	53.5
Nephrops	13.18	6.24	31.82	12.68	3.6	3.0	5.8	2.7
Total Demersal and Pelagic Fish	129.31	105.34	251.84	240.74	35.0	51.5	45.6	50.8

Table XVI. Percentage Monthly Landings of Shrimp and By-catch from the Fladen Ground by Scottish Vessels

(a) *Means for the years 1970-1975*

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Shrimp	88.9	-	79.1	73.0	79.3	67.0	63.2	60.4	55.8	36.8	40.0	65.2
Total By-catch	11.1	-	20.9	27.0	20.7	33.0	36.8	39.6	44.2	63.2	60.0	34.8
Total Demersal and Pelagic Fish	0	-	20.7	24.2	20.5	32.8	35.0	38.7	40.7	59.6	50.4	31.5

(b) *Means for the years 1976-1981*

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Shrimp	-	5.7	77.2	73.5	63.0	79.3	68.8	73.3	78.0	100.0	81.8	-
Total By-catch	-	95.3	22.8	26.5	37.0	20.7	31.2	26.7	22.0	-	18.2	-
Total Demersal and Pelagic Fish	-	95.3	21.8	26.1	34.6	20.1	29.6	26.6	20.4	-	18.2	-

Table XVII. Monthly Landings of Shrimp and By-catch as a percentage of Total Landings from the Farm Deeps (means for the Years 1977-1980) by British Vessels

	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.
Shrimp	47.1	43.5	44.8	57.7	58.3	47.6	32.5	59.5
Total By-catch	52.9	56.5	55.2	42.3	41.7	52.4	67.5	40.5
Total Demersal and Pelagic Fish	30.0	53.9	51.0	41.2	35.9	49.4	55.4	32.9

Fish Discards

Fish discarding at Fladen by the Scottish *Pandalus* fishery was described by Howard (1978 b). Samples of discards from commercial vessels were obtained during the period 1972-1977, and as far as possible monthly samples were taken throughout the fishing season. The results indicated that the proportion by weight of the total catch which was discarded varied considerably throughout the year (Table XVIII). The lowest proportion discarded, 7.1% by weight, was found in March. The proportion increased throughout the fishing season, reaching its highest levels, 75.0% in July and 73.3% in August. The predominant fish species discarded was Norway pout, *Trisopterus esmarkii* Nilsson, which accounted for between 57.6 and 93.9% by weight of discards. Further sampling in 1978 and 1979 confirmed these results.

Table XVIII. Proportions (%) by weight of shrimp, retained fish and discarded fish from commercial Scottish vessels on the Fladen grounds

	Shrimp	Retained fish	Discarded fish
1975			
May	65	18	17
June	39	21	40
July	45	10	45
August	77	7	16
1976			
March	87	6	7
April	75	12	13
May	62	19	19
June	49	8	43
July	39	10	51
August	64	12	24
1977			
March	56	15	29
April	57	18	25
May	55	24	21
June	54	17	29
July	28	11	61
August	21	6	73
1978			
March	75	18	7
April	67	11	22
May	33	15	52
June	30	12	58
July	39	7	54
1979			
April	45	22	33
May	41	20	39
June	77	11	12
July	22	3	75

In 1978, 1979 and 1981 samples of discards were obtained by FRV "Clupea" from both the Fladen and Farn Deeps. "Clupea" used shrimp trawls similar to those used by commercial vessels and operated under similar conditions. The results of this series of samples provided weights of discarded fin-fish ranging from 71% to 88% of the total catch at Fladen, and from 72% to

84% in the Farn Deeps. At Fladen, Norway pout again accounted for the highest proportion of discards, but on the Farn Deeps whiting constituted the major proportion of discards, up to 60% by weight. Norway pout accounted for up to 35% and sprat, herring and the hag fish, *Myxine glutinosa* L., each accounted for up to 10% of the discarded catch.

Munch-Petersen & Flintegard (1982), reporting on the discarded fish catches and fish landed for industrial purposes in the Danish *Pandalus* fisheries in the North Sea and the Skagerak, estimated that these fish constituted about 60% of the total catch.

Summary

The United Kingdom is a net importer of shrimps and prawns, and rising demand of shrimp products led, in 1970 to the participation by Scottish boats in a fishery for *Pandalus borealis* on the Fladen ground. This development was followed in 1977 by the exploitation of the *P. borealis* stock on the Farn Deeps. Landings of *P. borealis* rose from 102 tonnes in 1970 to 2,118 tonnes in 1978, but then declined rapidly owing to recruitment failure.

The principal fish by-catch species landed are cod, haddock, whiting, saithe and monk. At Fladen landings of fish by-catch constitute about 30% by weight and about 20% by value of all landings in the shrimp fishery.

Fish discarded, primarily Norway pout, accounts for up to 75% by weight of the total catch.

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